Renewable and Sustainable Energy Reviews 15 (2011) 534–543

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Market stimulation of renewable-based power generation in Australia

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ARTICLE INFO

Article history:
Received 6 July 2010
Accepted 12 August 2010

Keywords:
Australia
Energy policy
Renewable energies
Government subsidies

ABSTRACT

This paper attempts to identify the types of renewable-based power generation technologies available in Australia that have the capacity to contribute to the growth of the renewable energy sector and then suggest what type of economic incentive instruments could be applied in order to stimulate investment in that sector. Currently in Australia there are hydro, wind, bioenergy, solar, geothermal and ocean technologies being used to produce renewable power. Of these all except hydro power has large amounts of potentially useful resources. In the cases of wind, bioenergy, solar, and geothermal, the technology is mature enough to be immediately deployed in large-scale. However, only in the cases of wind and bioenergy the costs and return on investments are proven to be viable in the current market.

What is required on all fronts is an improved return on investments. Within the current electricity market competition with fossil-fuel based power is very difficult considering the ample supply of coal available in Australia and the heavy subsidies it receives. To become more competitive with electricity generated from coal-fired power plants, a feed-in tariff scheme could be implemented, and subsidies to the coal industry should be reduced if not removed. Another aspect impeding the growth of certain renewable power technologies is the high capital cost. This issue could be addressed with direct subsidies or tax exemptions, or aiding with easier access of finance options. However for particular industries such as wind and solar, it would be a further benefit if some effort is made to encourage component manufacturing within Australia.

For technologies that require further technical development, funding towards R&D or pilot projects, and support for international collaboration projects would accelerate their path to deployment. It is critical that the Australian government continues to be a leader. In addition to the Carbon Pollution Reduction Scheme (CPRS) and an extension to the Mandatory Renewable Energy Target Scheme (MRETS) proposed by the federal government, the Council of Australian Governments (CoAG) must work to streamline policies between the federal and state governments and the latter must apply policies unique to their region for what technology is prevalent.

Contents

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doi:10.1016/j.rser.2010.08.020

1. Introduction

In November 2007, the long standing Liberal Party government led by former Prime Minister John Howard folded after 11 years in power. The newly elected Prime Minister Kevin Rudd from the Australian Labour Party was applauded when on his first day in office on December 3rd 2007 he ratified the Kyoto Protocol. Since this symbolic date, the topic of climate change and greenhouse gas mitigation has been in the hot seat in Australia. For seven years now Australia has been suffering two record-breaking droughts – one of them widely considered "the worst drought in a thousand years" – and more recently was hit by a series of tropical storms caused by "La Niña" that put the whole city of Brisbane (the third largest city in Australia) under siege [1,2]. These kinds of extreme weather conditions are not unique to Australia; in fact they are affecting the whole world. The public concern for these evidently worsening effects of climate change and its synonymy with global warming is growing to a critical mass. Furthermore, Australia is one of the world's highest per-capita greenhouse polluters, in large part due to its heavy use of fossil-fuels. Australia is also recognised as the developed country most vulnerable to climate change [3] and therefore has a major stake in reducing emissions.

It is for these reasons that the new Rudd government proclaimed that a radical transformation was required in the way Australia produces, as well as uses energy, and following the ratification of the Kyoto Protocol, announced that Australia will commit itself to ensuring that 20% of its electricity supply comes from renewable energy sources by 2020. In order to achieve this target, an array of new policies were introduced, the most important of them being the national emissions trading scheme titled Carbon Pollution Reduction Scheme (CPRS) to be implemented in the beginning of 2010, and an extension to the Mandatory Renewable Energy Target Scheme (MRETS) by increasing the target in 2020 from 9500 GWh to 45,000 GWh.

The Australian Bureau of Agricultural and Resource Economics (ABARE) is a Government agency responsible for compiling national energy statistics. According to their report Energy in Australia 2008, the share of renewable-based power generation will only grow to 8% of the total electricity supply by 2020 without taking into account the CPRS proposed by the government. On the other hand, a report by McLennan Magasanik Associates (MMA) [4] commissioned by the Climate Institute predicts that the share of renewable-based power generation could be anywhere from 8.5% to 20% by 2020 depending on the type of policies and support mechanisms that are implemented.

It is worrisome to say the least to see that achieving the 2020 target is so dependent on the accurate implementation of policies, particularly when the timeframe for corrective action to mitigate greenhouse gas emission is limited. Australia is faced with a great challenge given that the current share of renewable-based power generation is less than 8% and the demand for electricity is expected to grow at a rate of 2% per annum [5]. The road to achieving the 20% target by 2020 and beyond must be complemented by streamlined state policies, industry support and ample investment.

2. Literature review

2.1. An Australian government initiative: 20% by 2020

Australia has seen a major shift in government leadership in recent years. After being in power for three terms beginning in 1996 and ending in 2007, John Howard, former head of the Liberal Party (right-wing equivalent) was defeated in the federal elections by opposition leader Kevin Rudd, from the Australian Labour Party (left-wing equivalent).

On his first day as prime minister, December 3rd 2007, Kevin Rudd ratified the Kyoto Protocol. Following this symbolic gesture it was announced that Australia will commit itself to ensuring that 20% of its electricity supply comes from renewable energy sources by the year 2020.

Since then the government has introduced two major initiatives, one the implementation of a national emissions trading scheme titled the Carbon Pollution Reduction Scheme (CPRS) and the other to extend the Mandatory Renewable Energy Target Scheme (MRETS) by increasing the target for 2020 from 9500 GWh to 45,000 GWh. Additional support is provided for renewable energy in the form of the AU$500 million Renewable Energy Fund which will develop, commercialise and deploy renewable energy technologies, the AU$150 million for solar and clean energy research, and more than AU$500 million for the Solar Cities, National Solar Schools, and Green Precincts initiatives [6].

2.1.1. Carbon Pollution Reduction Scheme (CPRS)

The Carbon Pollution Reduction Scheme (CPRS) is a national emissions trading scheme that has been proposed by the federal government planned to commence in 2010. The Scheme will cover only domestic emissions sources and sinks that are counted in Australia's Kyoto Protocol national account and all greenhouse gases listed under the Kyoto Protocol – carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, hydrofluorocarbons and

perfluorocarbons – will be covered from Scheme commencement. Every organisation with a facility that emits 25 kt of CO2-e or more per year will have to report and purchase a permit for every tonne of CO2-e it releases. This covers approximately 70% of Australia's emissions and includes most electricity generators, mining companies, large property trusts and other Australian Stock Exchange (ASX) 200 companies [7].

2.1.2. Mandatory Renewable Energy Target Scheme (MRETS)

The Mandatory Renewable Energy Target (MRET) scheme requires electricity retailers and other large buyers to purchase renewable energy certificates (RECs) from accredited renewable energy suppliers. This is designed to create a guaranteed market for renewable energy products. Energy suppliers are able to create certificates based on their renewable energy contribution. Liable retailers and other buyers must purchase enough of these certificates to meet their individual liability, either directly from accredited suppliers or by trading certificates with other parties. RECs are traded separately from the physical energy markets to ensure there is no interference with those markets. The number of RECs that liable parties must accumulate is based on their rank in the national electricity market. Renewable energy certificates are surrendered on 14th February each year. These certificates, therefore, are a form of 'currency' used to demonstrate compliance with the requirements of the MRET scheme [8].

As it can be observed in Table 1, the scheme has been quite successful in driving investments in new renewable energy projects.

Table 1
Increase in Renewable Generation under MRET Relative to 1997 (ABARE [8]). Reported generation under the Mandatory Renewable Energy Target scheme, above baseline levels in 1997.

	2004		2005		2006	
	GWh	Share (%)	GWh	Share(%)	GWh	Share (%)
Bagasse	249	7.6	588	12.7	466	9.7
Black liquor	121	3.7	127	2.8	129	2.7
Hydro	1061	32.3	1013	21.9	744	15.4
Landfill gas	322	9.8	362	7.8	519	10.8
Sewage gas	34	10	39	0.8	57	1.2
Photovoltaic	10	0.3	10	0.2	31	0.6
Solar water heater	807	24.6	906	19.6	1008	20.9
Wind	527	16.0	1415	30.6	1703	35.3
Wood waste	148	4.5	142	3.1	122	2.5
Other[a]	5	0 2	24	0.5	42	0.9
Total	3286	100	4626	100	4821	100

[a] Municipal solid waste combustion and food and agricultural wet waste.

2.2. Energy policies in Australia

Australia does not have a federal government body equivalent to the Department of Energy of the USA. Energy policies in Australia are subject to regulation and fiscal influence by all three levels of Government (federal, state and local), which are coordinated by the Council of Australian Governments (CoAG). The state and federal energy policy deals with primary industries, such as coal, while the local governments only implement state legislation relevant to that area.

On a national level, the responsible governmental agencies for energy policy are the Council of Australian Governments (CoAG), the Ministerial Council on Energy (MCE), the Commonwealth Department of Resources; Energy and Tourism (DRET), the Department of Environment and Heritage (DEH), the Department of Climate Change, the Office of the Renwable Energy Regulator, the Australian Energy Market Commission (AEMC), the Australian Energy Regulator (AER), and the National Electricity Market Management Company (NEMMCO).

2.3. Electricity network

Being a continent of 3700 km from North to South and 4000 km from East to West, Australia has an electricity network that covers large distances. With around $100 billion in assets, it covers more than 771,000 km of overhead transmission and distribution lines and more than 94,000 km of underground cables to link the generators and consumers [8].

Despite the vast landmass, approximately 50% of Australia's population lives on the narrow strip of coastline on the East, which include the three major cities of Sydney, Melbourne, and Brisbane. For this reason, as it can be seen from Fig. 1, the electricity network of Australia is a long and stringy network, stretching from far north Queensland to remote parts of South Australia, and since 2005 the

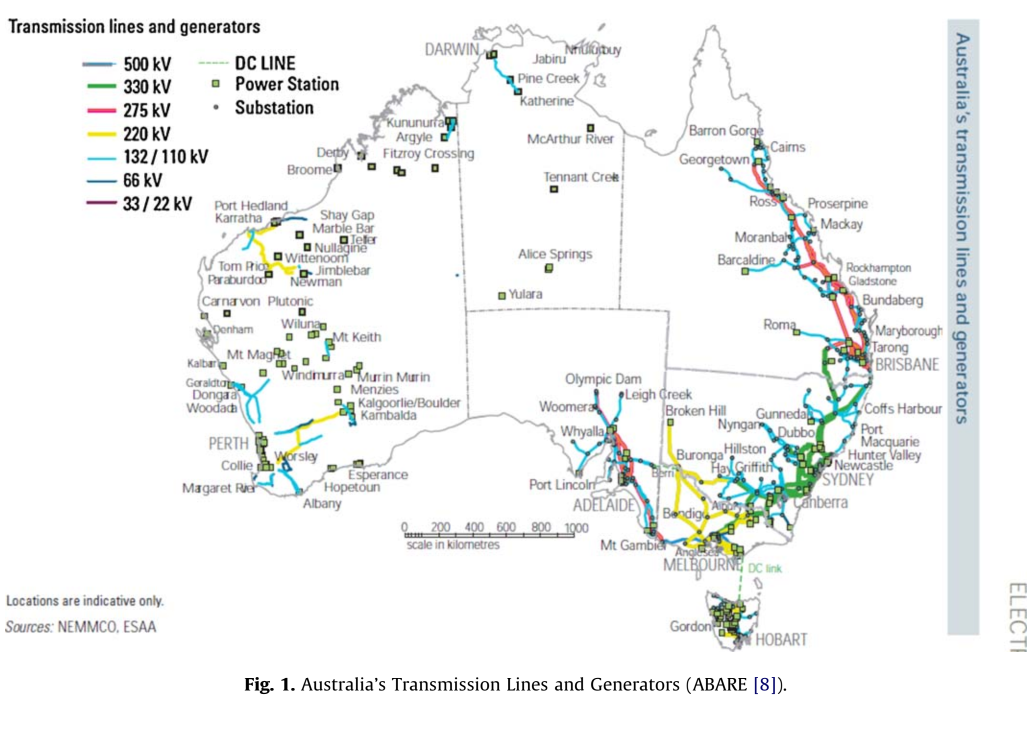


Fig. 1. Australia's Transmission Lines and Generators (ABARE [8]).

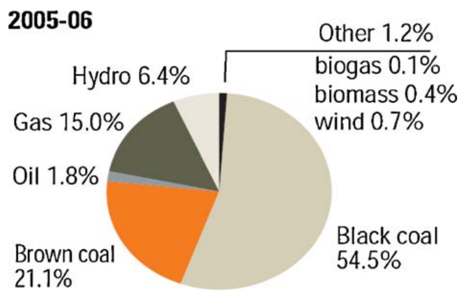


Fig. 2. Contribution to Electricity Supply by Fuel Source (2005–2006).

island state of Tasmania has been linked via an undersea cable called Basslink.

2.4. Current and projected electricity generation

To assess whether the current initiatives are adequate measures to achieve the proposed 2020 target, first it is important to have a look at the current sources of electricity supply and what the industry projects to be the future scenario.

2.4.1. Current electricity generation

According to the Bureau of Agricultural and Resource Economics (ABARE), Australia generated around 257 TWh of electricity in 2005–2006 from an estimated total installed capacity of 50 GW (Fig. 2).

Approximately 75% of electricity was generated by coal, 15% by gas, 6.4% by hydro, and 1.2% by other renewable technologies.

Overwhelmingly the main source of electricity generation is coal. The reason for this is the abundance of coal supply available in Australia. Industry experts estimate the supply of black coal in Australia to last 100 years and brown coal to last 500 years [8].

Hydro power constitutes the majority share of Australia's renewable power generation, followed by a moderate but growing number of wind turbines, biomass based on bagasse, and to a much lesser extent, solar power. The current share of renewable-based power generation is less than 8% of the total electricity supply.

2.4.2. Future projection

2.4.2.1. ABARE forecast. According to the ABARE report on Energy in Australia published in 2008, the demand for and supply of electricity is expected to continue to grow strongly, with electricity generation projected to reach 350 TWh by 2019–2020 (Fig. 3).

In the period 2019–2020 approximately 68% of electricity will be generated by coal, 22% by gas, 5.4% by hydro, and 3.1% by other renewable technologies.

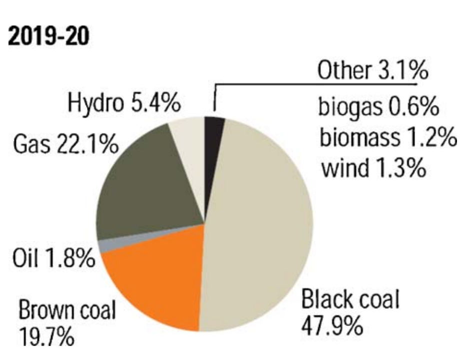


Fig. 3. Contribution to Electricity Supply by Fuel Source (2019–2020) [8].

Black coal is expected to remain the most commonly used fuel in electricity generation, although the share of natural gas is projected to rise by around 7% [8].

The share of hydro power is predicted to fall due to a low growth rate, while biomass and wind power generation is expected to increase, making the total share of renewable-based power generation of 8.5%. This is a far cry from the government target of 20%. However this forecast by ABARE does not include the effect of the newly proposed Carbon Pollution Reduction Scheme.

2.4.3. MMA forecast

The report published by McLennan Magasanik Associates (MMA) [4] is a popular reference for media and government departments alike. Its forecasts are based on six scenarios with varying levels of policy implementation. According to this report, to achieve the 20% target by 2020, the government must implement the CPRS with or without early implementation of emission caps but with a set price on carbon if no cap is enforced. Additional measures to encourage energy efficiency must also be implemented, so that an energy efficiency level of double historical rates is reached and maintained. Also the 45,000 GWh MRET must be met by 2020, and additional government support must be provided for demonstration and early deployment of carbon capture and storage and new renewable technologies such as solar thermal [4]. It is never explicitly stated in this report what the projected total electricity generation is for the year 2020. However by stating that the 20% target can be reached by 2020, one could assume that the MMA report forecasts the electricity supply in 2020 to be 300 TWh as opposed to the 350 TWh forecasted by the ABARE report. This could be attributed to the fact that the implementation of energy efficiency measures is expected to reduce the energy demand.

2.4.4. Will Australia reach its 2020 goal?

What both the ABARE report and the report by MMA show is that with minimal action there is virtually no hope of achieving a 20% renewable target by 2020.

The report by MMA demonstrates that it is possible to achieve the 20% renewable power target by 2020 but federal government policies must be implemented carefully and correctly, additional support mechanisms are critical, and that the public must be an active participant in reducing energy demand.

The Australian federal government appears to be in full action following the recommendations given by the MMA report. The new MRET has been set, the treatment of the emissions cap for the CPRS is being debated right now, and a new funding program for CCS has been announced [9].

However, despite all, it is still worrisome to see that achieving the 2020 target is so dependent on the accurate implementation of policies, particularly when the timeframe for taking action against global warming and climate change is so limited. Australia is faced with a great challenge to break away from the traditional sources of energy for power generation and increase the share of renewable-based power generation from 8% to 20% in 10 years. State policies must be streamlined with the federal government's initiatives to attract more investment in renewable-based power technologies and the people of Australia must be prepared to change in the way they use energy.

3. Methodology

With the implementation of policies such as the Carbon Pollution Reduction Scheme (CPRS), increased Mandatory Renewable Energy Target (MRET) and various subsidy programs, the federal government has clearly indicated a direction for the country. The CoAG and state governments are now poised to plan

and implement environmental and energy policies in a more streamlined manner, while adapting to unique situations in each region.

Australia is a large country with diverse geographical and climate features. Its five states and two territories have different kinds of renewable resources that are economically exploitable, which affect the type of policies that would be effective in promoting the growth of renewable energy technologies.

It is a common aspect, however, that more incentives need to be created for private individuals and industries to invest in renewable-based power generation if the target of 20% is to be achieved by 2020.

What this paper attempts to do is to identify for each renewable-based power generation technology available in Australia, the type of economic incentive that would assist in the stimulation and growth, so that government bodies can implement the most suitable one for their region.

The first step to this analysis is to identify the types of renewable-based power generation technologies that are available in Australia that have the capacity to contribute to the growth of the renewable energy sector. Then, for each technology, identify the factors that are limiting its growth. If the limitations are issues that can be addressed at least in part by economic incentives, the third part attempts to identify the type of economic incentive that could be applied.

3.1. Renewable-based power generation in Australia

Australia's renewable energy industry is diverse and includes bulk electricity generation from hydro power, wind power, bioenergy, as well as technologies and expertise in photovoltaics, geothermal, ocean power, solar hot water, remote area power systems and energy storage [10].

Australia has the potential for vast renewable energy capabilities, though these capabilities are not yet fully realised and the countries abundant resources are under-utilised. Solar and wind energy sources are being harnessed and are at the stage of commercialisation and other sources are being considered. At present, renewable energy sources contribute approximately 8–10% of Australia's total energy supply.

3.2. Hydro power

One of the earliest and most widespread forms of renewable energy in Australia, hydroelectric systems convert the potential energy of stored water to electrical energy by running it through water turbines [10].

Current facilities in Australia are mainly situated in Tasmania, in the Snowy Mountains in NSW and Koombooloomba in Far North Queensland. There are about 100 hydroelectric power stations in Australia covering a maximum of 7050 MW capacity, with a further 310 MW either under construction or planned for construction [11]. In the year 2005–2006 hydro power contributed to approximately 16.5 TWh (6.5%) of the total electricity supply.

However, in the next few decades, hydroelectricity generation is projected to grow only modestly by only 0.9% a year, reaching around 20 TWh by 2029–2030. This is a reflection of the limited availability of suitable locations for the expansion of large grid based hydroelectricity generation [8].

As it can be seen in the rainfall map of Australia (Fig. 4), there is not adequate rainfall except for a narrow coastal band on the east coast, where conservation restrictions often apply, limiting the potential growth of this technology.

Since the problems are mainly physical limitations, economic incentives are not going to contribute significantly to the growth of this technology.

However, opportunities still exist in Australia for small hydroelectricity generators on streams, in town water supplies and other places where there are regular water flows. The costs of producing electricity from small hydro where a new dam is not needed are similar to those of wind generation, and market mechanisms are required to ensure further roll out of small hydro [11]. This aspect will not be explored in this article as it will not have significant impact on the contribution to the 2020 target.

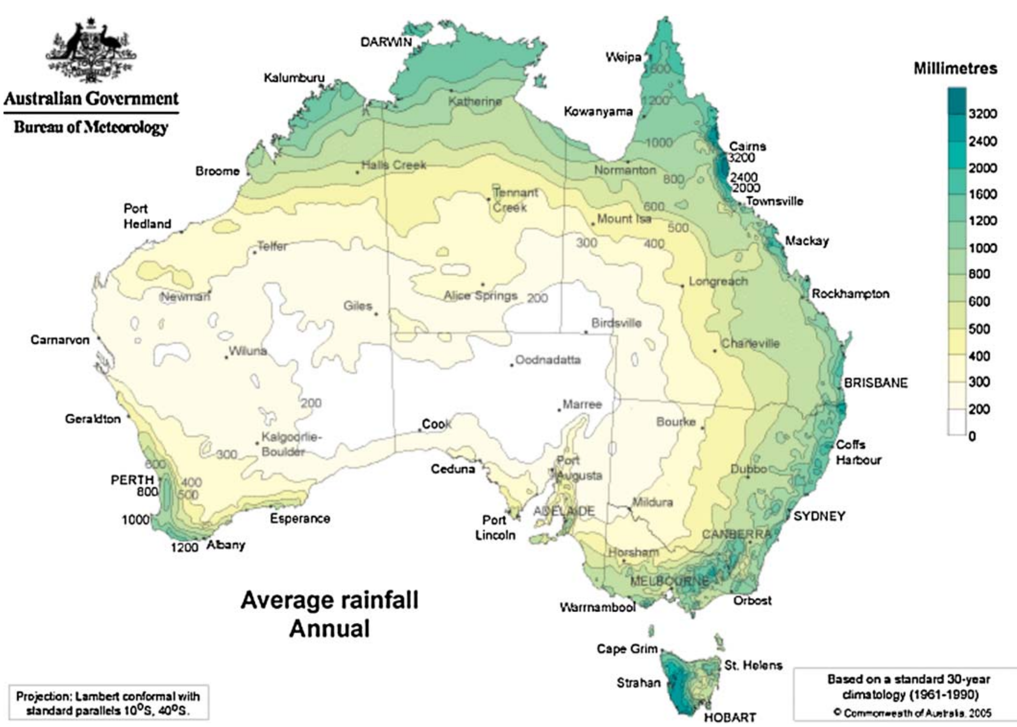


Fig. 4. Average annual and monthly rainfall, 2008.

3.2.1. Wind power

Wind energy, long used for water pumping in much of Australia has achieved recognition as a clean and cost-effective renewable energy source. It involves the generation of electricity from the naturally occurring power of the wind. Wind turbines capture wind energy within the area swept by their blades, proportional to the wind speed cubed, up to the designed maximum blade speed. The blades in turn drive an electrical generator to produce power for export to the grid [12].

There are currently 42 wind farms in operation with a total of 817 MW generating around 2500 GWh of electricity annually, contributing to about 2–3% of total electricity production [12]. Some of the largest wind farms are built in South Australia where 50% of Australia's wind power is produced. There are also some projects in New South Wales, Western Australia and Victoria.

Australia is blessed with some of the best and most reliable winds on earth. There are currently over 6000 MW of large-scale wind farms being investigated in Australia, which would cover nearly 19,000 GWh of electricity supply per year. In 2004, Iain MacGill and Hugh Outhred from UNSW suggested that 8000 MW could be installed in the National Electricity Market, and with further development in turbine technology this could be exceeded [12].

A report prepared for the Ministerial Council on Energy concluded that electricity from wind cost between $60 and $80 per megawatt hour (MWh), compared to $31 to $40/MWh for coal and $37 to $44/MWh for natural gas [13].

However, making comparisons between wind and other sources of energy can be difficult because of the cost profiles associated with wind developments. The vast majority of the costs associated with wind developments are upfront capital costs. The operating costs are relatively low, with each additional unit of wind power costing very little to produce. By comparison, conventional gas and coal developments have large capital costs, as well as significant operating costs. The difference in cost profiles creates difficulties when trying to compare the cost of alternative energy sources [13]. Despite these complexities, most of the data indicate that wind energy is one of the most cost efficient sources of renewable energy and that when the costs associated with pollution are factored in it is competitive with coal- and gas-fired power stations [13].

3.2.2. Issues

The main issue affecting the wind energy industry is its reliance on government enforced renewable energy targets. Prior to the 2007 Federal Election, the only guarantee the wind energy sector received was guaranteed access to a share of half a percent of the electricity market, or 9500 GWh, through the Mandatory Renewable Energy Target Scheme (MRETS). MRETS was created in part to level the disparity between high carbon emitting and low carbon emitting generation systems [14]. As mentioned already, the current Australian Labour Party Government has committed to a new MRET of 45,000 GWh by 2020 which is expected to further drive the growth of this technology. However, a large dependency on the MRET scheme implies that the wind power industry is at risk of facing stagnation again when the target is met, or if there is a change in the government support for the MRET scheme. For this reason it would be better to implement alternative economic incentive mechanisms to make the industry an attractive ground for investment regardless of the MRET scheme.

Currently there are no taxpayer subsidies for the wind energy industry. The developer must carry the entire financial liability for a project, which may cost anywhere from AU$100 million to AU$400 million, without government funding [12]. Investors are faced with a high capital cost, inhibiting from the growth of this technology. Therefore it would make sense to implement a system that reduces the initial capital required. Rather than direct subsidies which are likely to be costly for the government, some form of tax exemption strategy such as accelerated depreciation similar to those that benefit coal-fired power generators could be applied. A solution more unique to the industry however would be to encourage the establishment of wind turbine manufacturing in Australia. Currently there are no facilities for manufacturing large wind turbine systems in Australia and most components need to be imported from Europe or China which incurs a tremendous additional cost for transportation.

Another strategy would be to increase the return on investments for an accelerated payback period. A widely accepted strategy for increasing the return on investment for renewable-based power generation around the world is the application of feed-in tariffs. A feed-in tariff is a premium rate paid for electricity fed back into the electricity grid from a designated renewable electricity generation source. Currently there is no national feed-in tariff system in Australia, but there are some state-run schemes. The Victorian State Government for example runs a Standard Feed-in Tariff scheme for electricity generated from wind. However, this tariff applies only to systems of up to 100 kW of installed capacity, therefore do not benefit large-scale systems.

Another issue with wind power is through its inherent nature of intermittency, it is faced with some technical barriers with regards to connection to the grid. If a large percentage of the electricity grid is reliant upon an intermittent source with minimal predictability it can result in sudden losses of generation and cause major frequency problems and even blackouts. Also geographically in Australia wind power generators are normally at the margins of the national electricity grid. For new systems extra distribution and transmission networks need to be built and being at the ends of a long and stringy grid system unpredictable intermittency generation can result in major frequency oscillation problems. These types of technical barriers must be addressed to allow for the growth of wind power generation, which means investing in R&D for intermittency related grid connection issues and to encourage construction of transmission network infrastructure.

3.3. Bioenergy

Bioenergy is the conversion of sustainable biomass feed-stocks such as agricultural waste, manures, municipal organic waste, sewage gas and landfill gas into electricity, or electricity plus heat [10]. The fuel source of bioenergy can be stored and controlled. Plants can be used to generate electricity in many cases all year round, 24 h a day as base load power. Landfill gas plants, already in operation across all Australian capital cities, often operate for over 90 per cent of the year, comparable to traditional energy power stations [14].

Presently approximately 1.4% of Australia's electricity generation comes from bioenergy. Australia's sugar industry has used bioenergy to meet its electricity and heat requirements for over 100 years. Bioenergy resources are located across all the states of Australia, with most regions engaged in agriculture, forestry and food production producing substantial waste biomass that could be used to support power production [14].

According to the Bioenergy roadmap published by the Clean Energy Council of Australia, the biomass resource appraisal identified that an annual target of approximately 11,000 GWh can be delivered from an equivalent of about 1845 MW of installed capacity to 2020. This includes both existing and new capacity and is a realistic target for bioenergy in Australia based on current and anticipated energy market conditions and policies (Fig. 5).

3.3.1. Issues

Generally the technologies required to implement successful biomass-based stationary energy already exist in Australia or

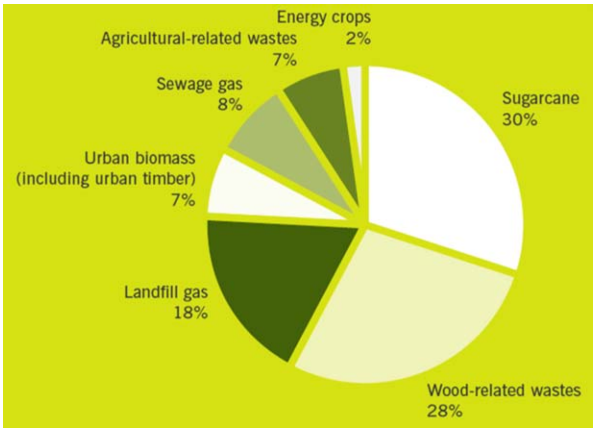


Fig. 5. The bioenergy target for electricity generation to 2020 by sector [15].

elsewhere in the world. Therefore the key to the success of bioenergy lies in the promotion of this technology. However bioenergy is largely overlooked by the media and politicians in favour of more high-profile technologies such as wind, hydro and solar. The challenge facing the industry is to create a much greater awareness and understanding of the potential of biomass to a broader range of stakeholder and customer groups [14].

Other countries, particularly in Europe, have various incentives and regulations at a federal level to promote bioenergy. Feed-in tariffs are the most common policy instrument and have proved to be most effective in Austria and Denmark. It was also identified that often the feed-in prices are customised to encourage uptake according to the size or technology employed by the bioenergy plant. Successful overseas experience of such programs can guide the establishment of sound criteria for Australia's bioenergy industry [15].

As mentioned already, currently there is no national feed-in tariff system in Australia, only some state-run schemes. The Victorian State Government for example runs a Standard Feed-in Tariff scheme for biomass plants. However, this tariff applies only to systems of up to 100 kW and therefore do not benefit most commercial or industrial plants.

Apart from this, a unique opportunity exists for bioenergy in Australia. Given the large landmass and minimal population, there are vast areas of land covered by eucalyptus trees and an invasive species called mimosa. The potential for converting these raw materials into bioenergy is being explored by some pilot projects in Western and Northern Australia [16]. With some government support in developing these kinds of alternative biomass fuel sources, the potential for bioenergy in Australia could be extended even more.

3.4. Solar power

There are several ways to harness the energy of the sun. The most widely recognised method for generating electricity using solar power is by using Solar Photovoltaic (PV) systems. PV panels on the roofs of homes and businesses capture the sun's energy to generate electricity cleanly and quietly. Light energy is converted directly into electricity by transferring sunlight photon energy into electrical energy. This conversion takes place within cells of specially fabricated semiconductor crystals [17].

Today solar PV power is installed on around 25,000 homes across Australia. Solar PV also has a long history of supplying reliable 'off the grid' power to outback and regional communities, with isolated telecommunications and repeater stations, transport signalling, and working properties supported by a large number of solar PV installations [17].

Despite the country having reputation for a hot dry and sunny climate that would make it ideal for utilisation, less than 2% of energy is sourced from solar power.

Most large-scale installations are located in the state of New South Wales and the Northern Territory, the largest system being the 408 kW PV installation in Singleton NSW owned by Energy Australia. Surprisingly there are no prominent projects in the state of Queensland which is known as the "sunshine state".

According to The Australian Photovoltaic Industry Roadmap III published by the Australian Business Council for Sustainable Energy in 2004, the PV industry can grow to an installed capacity of 6740 MW by 2020, which could supply 9320 MWh of electricity supply per year [18].

3.4.1. Issues

The issue for the Australian photovoltaics industry today is that there is enormous market potential but the industry is not yet self-sustaining. The main impediment to growth is the lack of a consistent national policy that recognises the contribution solar PV can make to Australia's climate change response [17].

The federal government has responded to this issue in part by raising the MRET to 45,000 GWh by 2020 and by continuing with rebate schemes such as the Solar Homes and Communities Plan, Residential and Medium-scale sub-program, Renewable Remote Power Generation Program and Solar Cities Program.

In addition, the current government is planning to implement a Green Loan Program of up to $10,000 with a reduced interest rate to Australian families to install solar, water saving, and energy efficient domestic appliances. Although this will help with the installation of small-scale solar systems, it will not benefit large-scale generation systems.

However, solar technologies are still faced with relatively high capital costs resulting in a higher cost per kW than other power sources which inhibit it from large-scale exploitation.

Current coal-based grid electricity prices do not reflect a range of environmental, technical and social externalities which are borne by the community and which would be reduced for each kWh substituted by PV generation. There are a number of unpriced benefits that PV provides, which are not currently recognised and rewarded [18].

Similar to the case with wind power, a means to reduce the initial capital costs would aid in the growth of this industry. Again, for large-scale systems a direct subsidy would be too costly for the government. Therefore some form of tax exemption such as accelerated depreciation similar to those that benefit coal-fired power generators could be applied. The manufacturing of PV cells are prevalent in Australia however other components such as DC converters and power control systems capable for large-scale systems must be imported due to the lack of manufacturing facilities. Therefore it would be beneficial also for the government to encourage the growth of this industry within Australia.

Another method to encourage investment in this technology is to increase the return on investment by applying feed-in tariffs. In fact it is proposed as the optimum industry development method for grid-connected systems. Feed-in tariffs work by arranging for all PV customers to be paid a higher price for electricity produced from their PV system. This approach has been demonstrated to be very effective in a number of countries such as Germany and Spain. The higher value for the power produced reflects the considerable benefits that distributed PV systems provide to the electricity distribution system that are not currently recognised, nor rewarded. These include contribution to meeting peak power requirements and network integrity and security (ABCSE [18]).

Currently there is no national feed-in tariff scheme in Australia, however there are some state-run schemes. The Queensland State

Government for example runs a scheme that pays AU$0.44+ per kW for electricity generated from solar PVs. However, this tariff applies only to systems of up to 10 kW in size, therefore do not benefit large-scale systems. For the feed-in tariff schemes to be beneficial for the growth of solar power technologies, it must apply to all system sizes and be a gross metering feed-in tariff set high enough and for long enough [17].

Another useful scheme that could be implemented for the promotion of solar PVs is incorporating the installation of PV cells in Codes and Standards for new buildings. A number of state governments are implementing mandatory minimum energy performance standards for new residential buildings. This provides an important opportunity for PV to be incorporated into new residential buildings and provides building developers with a number of options to meet the greenhouse reduction requirements.

This model should be developed and rolled out into other states and also roll out into new non-residential buildings. States such as Victoria and South Australia have introduced minimum five star energy efficiency requirements for new residential buildings. At present these schemes do not give credit to customers who install PV, but there is potential for this to occur in the future. All energy performance schemes should appropriately recognise and reward the contribution of PV systems to electricity supply for the building envelope [18].

As the sunniest continent in the world, there is massive potential for solar PV to make a significant contribution to electricity generation in Australia. Couple this unrivalled resource with a multitude of open spaces, and there is no reason why Australia cannot have large-scale installations generating many megawatts of electricity for sale into the grid [17].

3.5. Geothermal

Geothermal energy is produced by using the internal heat of the earth to extract usable heat to create electricity, generate hot water or heat buildings. Heat is naturally generated in special granite rocks located deep below the Earth's surface and is trapped there by layers of insulating sedimentary rocks. These are sometimes called Hot Dry Rocks (HDR), Hot Fractured Rocks (HFR) or Enhanced Geothermal Systems (EGS). Getting the energy from the hot rocks relies on techniques established by the oil and gas industry. Wells are drilled to a depth of 3–5 km below the surface to find the heat-producing granites. Water is then pumped down in the wells and through the cracks in the rocks. The water is heated to a temperature of up to 300 °C and pushed back to the surface where the heat is used to drive a turbine and produce electricity. The water used is recycled [15]. One of the significant features of hot rock generation technologies is that it has the potential to provide base load power unrestrained by the environmental conditions that inhibit renewable energy technologies at the surface [8].

While some of the world's best sites for hot rocks are in Australia, at this stage the only working geothermal power station in Australia is in Birdsville, Queensland. It uses hot water from the Great Artesian Basin and is rated at 120 kW.

According to the report to the Australian Geothermal Energy Association (AGEA) by McLennan Magasanik Associates, up to 2200 MW of baseload capacity can be expected to be provided by the Australian geothermal energy industry into Australia's electricity market by 2020 based on current government policy settings. This capacity could represent an electricity supply of up to 18 TWh per annum at a cost from around AU$80 per MWh [19].

There are currently 19 companies Australia-wide spending AU$654 million in exploration programmes in 141 areas. In South Australia, which is expected to dominate the sector's growth, 12 companies have already applied for 116 areas and can be expected to invest AU$524 million in their projects by the next six years. Ten projects are expected to achieve successful exploration and heat flows, by 2010, with at least three power generation demonstration projects coming on stream by 2012 (Louthean [20]). The major areas of exploration in Australia are the Cooper/Eromanga Basin in South Australia, the Hunter Valley near Newcastle, Otway Basin in Victoria, and Tasmania.

3.5.1. Issues

Geothermal energy in Australia is still in its early stages and requires a lot of support for R&D and for running pilot projects. The current government has dedicated AU$50 million from the AU$500 million Renewable Energy Fund to the Geothermal Drilling Programme, which is a merit based, competitive program to support proof of concept projects that involve drilling two geothermal wells and establishing an underground heat exchanger. The industry is also subject to various state-based funds. Furthermore Australia recently formed the International Partnership for Geothermal Technology together with the United States and Iceland. The Partnership is expected to accelerate the development of geothermal technology through international cooperation.

Once pilot plants have been proven and the technology moves towards deployment, the biggest issue is likely to be network connection. Work will need to be undertaken to ensure that network access arrangements do not discriminate against more remote locations of this technology source [15].

3.6. Ocean power

Ocean power uses the oceans' tides, currents or waves to produce electricity. Power comes from either the changes in height of the water or the flow of the water. Almost all commercial ocean based power generation systems use a hydro turbine to convert water flow to rotating mechanical energy to drive an electrical generator.

3.6.1. Tidal

A tidal power station is part of a dam, or barrage, built across a narrow bay or river mouth. As the tide flows in or out, it creates uneven water levels on opposite sides of the barrage. Water flows from the high side to the low side through turbines to generate electricity.

3.6.2. Current

Underwater turbines, similar to wind turbines, collect the energy in tidal and ocean currents. In water moving between 6 and 9 km per hour, a 15 m diameter water turbine could generate as much energy as a 60 m diameter wind turbine.

3.6.3. Wave

Surface waves and pressure variations below the ocean's surface can generate intermittent power. Floating buoys, platforms, or submerged devices placed in deep water, generate electricity using the bobbing motion of the ocean's waves.

There has been much interest in ocean power in Australia. Australian company Oceanlinx has installed a 500 kW wave power unit at Port Kembla, NSW, and plans to install 10 units in Portland, Victoria with a peak capacity of 15 megawatts. The Victorian unit has the potential to supply the power needs of about 15,000 homes in the local area. Australia has some very promising ocean power resources with huge tides in some areas (such as the Kimberley coast in WA) and strong currents close to shore. The majority of the Australian population lives near the coast reducing the high costs of grid connection. The industry needs to do more research to determine the size of the resource.

Table 2
Summary of results [4].

Technology	Existing capacity	Potential capacity	Limitations	Type of economic incentives
Hydro	7050 MW 16.5 TWh	20 TWh	Geographical suitability	N/A
Wind	824 MW 2500 GWh	6000 MW investigated 19 TWh	High capital cost Network connection	Tax exemption Feed-in tariff Manufacturing in Australia
Bioenergy	1400 GWh	1845 MW 11 TWh	Lack of awareness R&D support	Funding for alternative fuel projects Feed-in tariff
Solar PV	150 GWh	6740 MW 9320 GWh	High capital cost	Tax exemption Feed-in tariff Manufacturing in Australia
Geothermal	120 kW	2200 MW 18 TWh	R&D support Network connection	Funding for technology and exploration Feed-in tariff
Ocean	500 kW	15 MW+	R&D support	Funding for R&D
Total		77.32 TWh+		

Steady ocean currents provide good baseload power; tidal power is diurnal and is highly predictable; and waves are predictable days in advance making it easier for the energy market to balance supply and demand.

3.6.4. Issues

Ocean technology needs support for research and development and studies to map the potential sites for installations. These ocean technologies are all in their infancy of development and are more expensive than most other technologies. However, as the technologies are developed the costs will drop substantially.

4. Results

The Australian Government's aim is to source 20% of its electricity supply from renewable-based power generation by the year 2020. Based on the report by McLennan Magasanik Associates [4], the electricity supply for 2019–2020 will be 300 TWh. This indicates that 60 TWh of electricity must be sourced from renewable-based power generation.

Table 2 shows a summary of the energy predicted to be sourced from each renewable resource in Australia.

The results summarised in this table indicate that there is sufficient capacity in renewable-based power generation to meet the 20% target.

The forecasted generation figures however, are based on certain assumptions about policy implementation and additional support by various government bodies, industry and the general public. The details of which are outlined in each respective roadmap reports.

The main concern however is the type of obstacles these technologies face in order to achieve the desired growth. Each technology is unique in its situation however there are some common limitations that can be addressed by certain economic incentive mechanisms.

Where the problem is high capital cost, a direct subsidy or tax exemption could be applied. A direct subsidy would be more suitable for small-scale systems, for example, the installation of a small PV system in a private home. For a large-scale system, some form of tax exemption would be more suitable as the cost incurred to the governing body would be less. Another solution to assist with the barrier of high capital costs is to arrange a loan scheme or provide easier access to a loan with a reduced interest rate.

Particularly for the wind and solar industries, there is a lack of manufacturing facilities in Australia. This contributes to the increased cost of capital investment by way of having to import major components. Government action to encourage the creation or relocation of manufacturing industry would be beneficial.

A common problem for all renewable-based power generation except possibly for hydro power is that the cost per kW of electricity generated is higher than fossil-fuel based energies. A widely accepted approach to making prices more competitive is the application of feed-in tariffs. Currently there is no national feed-in tariff scheme in Australia, only some state-based schemes. However in all cases the feed-in tariffs apply only to small-scale systems and of these most apply only to solar PV systems. Another course of action to make renewable-based power competitive with conventional power would be to remove, if not reduce the subsidies given to the coal industry in Australia.

For certain technologies such as geothermal and ocean power where certain technological issues remain, funding and support for R&D, pilot projects and international collaboration projects would be beneficial to get them up to a commercially viable state.

Grid connection may be an issue for wind and geothermal technologies as in most cases they are geographically isolated or at the margins of the national electricity grid. Transmission and distribution companies should be encouraged to at least share in the building of infrastructure in order to reduce the cost of the technology owner having to build feed-in networks and control equipment in addition to the plant cost.

5. Conclusions

Currently in Australia there are hydro, wind, bioenergy, solar, geothermal and ocean technologies being used to produce renewable power. Of these all except hydro power have large amounts of potentially useful resources. In the cases of wind, bioenergy, solar, and geothermal, the technology is mature enough to be immediately deployed in large-scale. However, only in the cases of wind and bioenergy the costs and return on investments are proven to be viable in the current market.

What is required on all fronts is an improved return on investments. Within the current electricity market competition with fossil-fuel based power is very difficult considering the ample supply of coal available in Australia and the heavy subsidies it receives. To become more competitive with electricity generated from coal-fired power plants, a feed-in tariff scheme could be implemented, and subsidies to the coal industry should be removed if not reduced.

Another aspect impeding the growth of certain renewable power technologies is the high capital cost. This issue could be addressed with direct subsidies or tax exemptions, or aiding with easier access of finance options. However for particular industries such as wind and solar, it would be a further benefit if some effort was made to encourage component manufacturing within Australia.

For technologies that require further technical development, funding towards R&D or pilot projects, and support for international collaboration projects would accelerate their path to deployment.

As the statement "Sustainable development must rest on political will" from the Brutland Report cited by Curran [22] indicates, it is critical that the Australian government continues to be a leader. In addition to the CPRS and MRETS proposed by the federal government, the Council of Australian Governments (CoAG) must work to streamline policies between the federal and state and the state governments must apply policies unique to their region for what technology is prevalent. They can do this by implementing a feed-in tariff scheme to improve the return on

capital, giving subsidies to small-scale systems or R&D projects, augmenting finance options to reduce the burden of the capital funds, or initiating pilot projects or encouraging international collaboration for technology development. On a federal level it would be critical to plan, implement, and continually adjust the CPRS and MRETS as best as possible, phase out coal subsidy, and put in policies that encourage more component manufacturing in Australia.

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